

# AEO2003 Overview

## Key Energy Issues to 2025

As has been typical over the past few years, energy prices were extremely volatile during 2002. Spot natural gas prices, about \$2 per thousand cubic feet in January, rose to between \$3 and \$4 per thousand cubic feet by the fall. Average wellhead prices, which are moderated by the inclusion of natural gas bought under contract, also increased over the year. Crude oil prices also rose in 2002, mainly because of reduced production by the Organization of Petroleum Exporting Countries (OPEC) and, to a lesser degree, fears about the potential impact of military action in Iraq. Crude oil prices began 2002 at roughly \$16 per barrel and were between \$25 and \$30 per barrel by the fall.

The impact of near-term price trends is reflected in the *Annual Energy Outlook 2003* (AEO2003), but long-term energy markets are less influenced by near-term trends, such as supply disruptions or political actions, and more by the long-term fundamentals of energy markets. AEO2003 focuses on these long-term fundamentals, including the availability of energy resources, developments in U.S. electricity markets, technology improvement, and the impact of economic growth on projected energy demand and prices through 2025.

A major consideration for energy markets through 2025 will be the availability of adequate natural gas supplies at competitive prices to meet growth in demand. AEO2003 projects growing dependence on major new, large-volume natural gas supply projects for both domestic and imported supplies to meet future demand levels, including deepwater offshore wells, new and expanded liquefied natural gas (LNG) facilities, the Mackenzie Delta pipeline in Canada, and an Alaskan pipeline that would allow delivery of natural gas to the lower 48 States.

Net imports accounted for 55 percent of total U.S. oil demand in 2001, up from 37 percent in 1980 and 42 percent in 1990. That trend is expected to continue. A growing portion of imports is projected to be refined petroleum products, such as gasoline, diesel fuel, and jet fuel, assuming the future availability of those products in world markets.

While no new nuclear plants have been built in recent years, existing facilities have substantially improved their performance and lowered operating costs. Further, it has become common practice to request extension of the operating licenses of nuclear plants from the U.S. Nuclear Regulatory Commission (NRC). As a result, the downturn in nuclear generating capacity and generation previously expected is now anticipated to be delayed or eliminated. A more

recent phenomenon has been uprating of nuclear plant capacity. The AEO2003 forecast, reflecting those trends, projects an increase in nuclear capacity and generation.

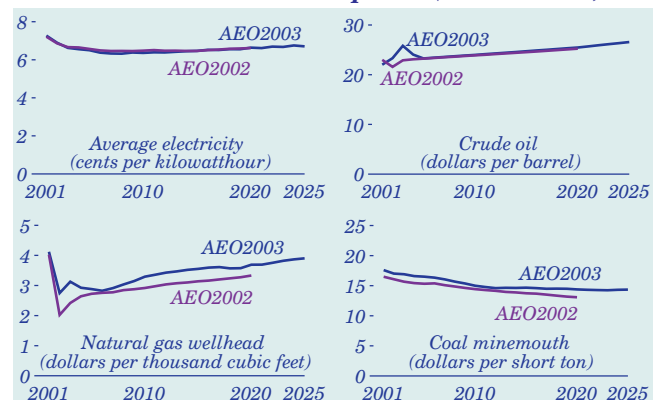
## Economic Growth

The U.S. economy, as measured by gross domestic product (GDP), is projected to grow at an average annual rate of 3.0 percent from 2001 to 2025 in AEO2003, similar to the 3.1 percent rate projected in AEO2002 for 2001 to 2020. Most of the determinants of economic growth are similar to those in AEO2002, but there are some important differences. For example, the projection of vehicle miles traveled, estimated using macroeconomic variables such as GDP growth, population, and income, is higher in this year's AEO. Light-duty vehicle miles traveled are projected to grow by 2.4 percent per year through 2020 in AEO2003, compared with 2.2 percent in AEO2002. This projection, which is more consistent with recent historical trends, increases the projected demand for transportation fuels.

## Energy Prices

The average world oil price is projected to increase from \$22.01 per barrel (2001 dollars) in 2001 to \$25.83 per barrel in 2003, then to decline to \$23.27 per barrel in 2005. Rising prices are projected for the longer term, to roughly \$25.50 in 2020 (about the same as in AEO2002) and roughly \$26.50 in 2025 (Figure 1), largely due to higher projected world oil demand. In nominal dollars, the average world oil price is expected to reach approximately \$48 per barrel in 2025.

**Figure 1. Energy price projections, 2001-2025: AEO2002 and AEO2003 compared (2001 dollars)**



World oil demand is projected to increase from 76.0 million barrels per day in 2001 to 112.0 million barrels per day in 2020 (less than the AEO2002 projection of 118.9 million barrels per day) due to lower

projected demand in the former Soviet Union and in developing nations, including China, India, Africa, and South and Central America. World oil demand, including both conventional and unconventional oil supplies, grows to 123.2 million barrels per day by 2025 in *AEO2003*. Growth in oil production in both OPEC and non-OPEC nations leads to relatively slow growth in prices through 2025. OPEC conventional oil production is expected to reach 60.1 million barrels per day in 2025, more than double the 28.3 million barrels per day produced in 2001. The forecast assumes that sufficient capital will be available to expand production capacity.

Non-OPEC conventional oil production is expected to increase from 45.5 to 58.8 million barrels per day between 2001 and 2025. A 1.0 million barrel per day decline in production in the industrialized nations (United States, Canada, Mexico, Western Europe, Japan, Australia, and New Zealand) is more than offset by increased production from Russia, the Caspian Basin, Non-OPEC Africa, and South and Central America (in particular, Brazil). Russian oil production is expected to continue to recover from the lows of the 1990s and to reach 10.4 million barrels per day by 2025, 44 percent above 2001 levels. Production from the Caspian Basin is expected to exceed 5.0 million barrels per day by 2025, compared with 1.6 million barrels per day in 2001. By 2025, projected production from South and Central America reaches 6.3 million barrels per day, up from 3.7 million barrels per day in 2001. Non-OPEC African production is projected to grow from 2.7 million barrels per day in 2001 to 6.9 million barrels per day by 2025.

Average natural gas prices (including spot purchases and contracts) are projected to drop from \$4.12 per thousand cubic feet in 2001 to \$2.75 per thousand cubic feet in 2002. After 2002, natural gas prices are projected to move higher as technology improvements prove inadequate to offset the impacts of resource depletion and increased demand. Natural gas prices are projected to increase in an uneven fashion as higher prices allow the introduction of major new, large-volume natural gas projects that temporarily depress prices when initially brought on line. Prices are projected to reach about \$3.70 per thousand cubic feet by 2020 and \$3.90 per thousand cubic feet by 2025 (equivalent to more than \$7.00 per thousand cubic feet in nominal dollars).

At roughly \$3.70 per thousand cubic feet, the 2020 wellhead natural gas price in *AEO2003* is more than 35 cents higher than the *AEO2002* projection, due to a downward revision of the potential for inferred

natural gas reserve appreciation and a reduced expectation for technology improvement over time. As demand for natural gas increases, expected technology improvements do not completely offset the effects of resource depletion.

In *AEO2003*, the average minemouth price of coal is projected to decline from \$17.59 in 2001 to about \$14.40 per short ton (2001 dollars) in 2020, remaining at about that level through 2025. Prices decline because of increased mine productivity, a shift to western production, and competitive pressures on labor costs. *AEO2003* is less optimistic about future productivity improvements in the Powder River Basin than was *AEO2002*, which projected average coal prices of roughly \$13.10 per ton by 2020.

Average electricity prices are projected to decline from 7.3 cents per kilowatthour in 2001 to a low of 6.3 cents (2001 dollars) by 2007 as a result of cost reductions in an increasingly competitive market where excess generating capacity has resulted from the recent boom in construction and the continued decline in coal prices. Electricity industry restructuring contributes to declining projected prices through reductions in operating and maintenance costs, administrative costs, and other miscellaneous costs. After 2008, average real electricity prices are projected to increase by 0.4 percent per year as a result of rising natural gas prices and a growing need for new generating capacity to meet electricity demand growth. Real electricity prices reach 6.6 cents per kilowatthour in 2020 in *AEO2003*, identical to the price in *AEO2002*, and 6.7 cents per kilowatthour by 2025 as natural gas prices continue to increase.

### Energy Consumption

Total energy consumption in *AEO2003* is projected to increase from 97.3 to 130.1 quadrillion British thermal units (Btu) between 2001 and 2020, an average annual increase of 1.5 percent. This projection is slightly below the 2020 projection of 130.9 quadrillion Btu for total consumption in *AEO2002*. By 2025, total energy consumption is projected to reach 139.1 quadrillion Btu in *AEO2003*. While total energy consumption levels in 2020 are similar in *AEO2002* and *AEO2003*, consumption by sector shifts; in particular, transportation consumption is higher and industrial consumption is lower by 2020 in *AEO2003*.

Residential energy consumption is projected to grow at an average rate of 1.0 percent per year between 2001 and 2025, with the most rapid growth expected for computers, electronic equipment, and appliances. By 2020, projected residential demand is 24.5

quadrillion Btu (slightly higher than the 24.3 quadrillion Btu projected in *AEO2002*). Slightly greater growth in the number of households explains the relatively higher level of energy demand in *AEO2003*. By 2025, total residential energy consumption is projected to reach 25.4 quadrillion Btu.

Commercial energy demand is projected to grow at an average annual rate of 1.6 percent between 2001 and 2025, reaching 23.5 quadrillion Btu in 2020 (slightly higher than the 23.2 quadrillion Btu in *AEO2002*) and 25.3 quadrillion Btu by 2025 in *AEO2003*. The most rapid increases in demand are projected for computers, office equipment, telecommunications, and miscellaneous small appliance uses. Commercial floorspace is projected to grow by an average of 1.6 percent per year between 2001 and 2020, identical to the rate of growth in *AEO2002* for the same time period.

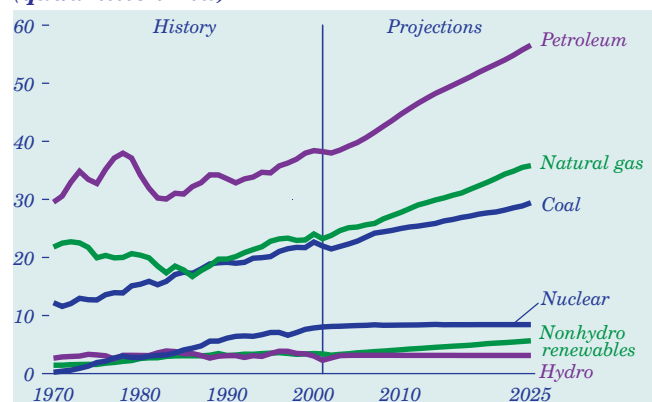
Industrial energy demand in *AEO2003* is projected to increase at an average rate of 1.3 percent per year between 2001 and 2025, reaching 41.7 quadrillion Btu in 2020 (significantly lower than the *AEO2002* projection of 43.8 quadrillion Btu) and 44.4 quadrillion Btu in 2025. The lower level of energy consumption in *AEO2003* in 2020 is partly the result of adopting an updated definition of what is included in industrial energy consumption. In earlier *AEOs*, industrial energy consumption included demand by combined heat and power (CHP) plants that were essentially independent power producers (IPPs), producing electricity but little steam. The energy demand of such “nontraditional” CHP plants is now included in the electric power sector.

Transportation energy demand in *AEO2003* is projected to grow at an average annual rate of 2.0 percent between 2001 and 2025, reaching 40.4 quadrillion Btu in 2020 (0.8 quadrillion Btu higher than in *AEO2002*) and 44.0 quadrillion Btu by 2025. The higher level of consumption in the transportation sector results from a higher forecast of vehicle miles traveled and a lower level of vehicle efficiency. Light-duty vehicle miles traveled are projected to grow by 2.4 percent per year through 2020 in *AEO2003* (compared with 2.2 percent per year in *AEO2002*) and by 2.3 percent per year through 2025. Consistent with recent trends, less improvement is projected for the average fuel efficiency of new light-duty vehicles than in *AEO2002*. New light-duty vehicle efficiency is projected to reach 25.6 miles per gallon by 2020 in *AEO2003* (down from 27.2 miles per gallon in *AEO2002*) and 26.1 miles per gallon by 2025.

Total electricity demand is projected to grow by 1.9 percent per year from 2001 through 2020 (the same as in *AEO2002*) and 1.8 percent per year from 2001 to 2025. Rapid growth in electricity use for computers, office equipment, and a variety of electrical appliances in the residential and commercial sectors is only partially offset by improved efficiency in these and other more traditional electrical applications; however, demand growth is expected to slow as regional and national market saturation is reached for air conditioning and some other applications.

Total demand for natural gas is projected to increase at an average annual rate of 1.8 percent between 2001 and 2025 (Figure 2), from 22.7 trillion cubic feet to 34.9 trillion cubic feet, primarily because of rapid growth in demand for electricity generation. With higher projected prices, total natural gas demand in 2020 (32.1 trillion cubic feet) is projected to be 1.6 trillion cubic feet lower in *AEO2003* than in *AEO2002*.

**Figure 2. Energy consumption by fuel, 1970-2025 (quadrillion Btu)**



In *AEO2003*, total coal consumption is projected to increase from 1,050 to 1,444 million short tons between 2001 and 2025, an average increase of 1.3 percent per year. Projected total coal demand in 2020 (based on short tons) is almost identical to that in *AEO2002* despite some shifts between sectors. Industrial coal demand is lower and electricity generation coal demand is higher in *AEO2003* as a result of the definitional changes in the data mentioned above and higher natural gas prices in *AEO2003* that lead to higher projected demand for coal in the electric power sector.

Total petroleum demand is projected to grow at an average annual rate of 1.7 percent through 2025 (reaching 29.17 million barrels per day), led by growth in the transportation sector, which is expected to account for about 75 percent of petroleum



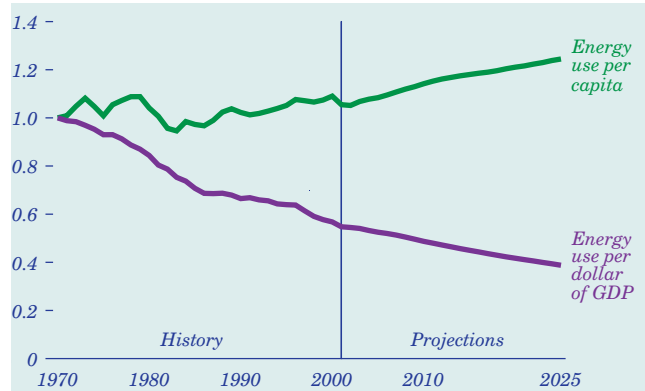
demand in 2025. Projected demand in 2020 (27.13 million barrels per day) is higher than in *AEO2002* by 470 thousand barrels per day due to higher transportation demand.

Total renewable fuel consumption, including ethanol for gasoline blending, is projected to grow at an average rate of 2.2 percent per year through 2025, primarily due to State mandates for renewable electricity generation. About 55 percent of the projected demand for renewables in 2025 is for electricity generation and the rest for dispersed heating and cooling, industrial uses (including CHP), and fuel blending. The projected demand for renewables in 2020 in *AEO2003* is 0.6 quadrillion Btu lower than in *AEO2002*, reflecting an update in historical statistics primarily regarding electricity generation at pulp and paper plants that lowers the expectation for biomass use at industrial CHP plants.

### Energy Intensity

As energy prices increased between 1970 and 1986, energy intensity, as measured by energy use per dollar of GDP, declined at an average annual rate of 2.3 percent as the economy shifted to less energy-intensive industries, product mix changed, and more efficient technologies were adopted (Figure 3). With slower price increases and growth in more energy-intensive industries, intensity declines moderated to an average of 1.4 percent per year between 1986 and 2001. Energy intensity is projected to continue to decline at an average annual rate of 1.5 percent through 2025, as continued efficiency gains and structural shifts in the economy offset growth in the demand for energy services.

**Figure 3. Energy use per capita and per dollar of gross domestic product, 1970-2025 (index, 1970 = 1)**



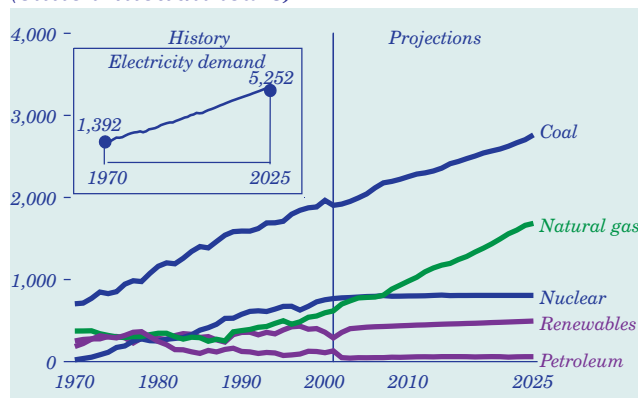
Energy use per person generally declined from 1970 through the mid-1980s but began to increase as energy prices declined in the late 1980s and 1990s.

Per capita energy use is projected to increase in the forecast, with growth in demand for energy services only partially offset by efficiency gains. Per capita energy use increases by 0.7 percent per year between 2001 and 2025 in *AEO2003*.

### Electricity Generation

Generation from natural gas, coal, nuclear, and renewable fuels is projected to increase through 2025 to meet growing demand for electricity and offset the projected retirement of existing generating capacity, mostly fossil steam capacity being displaced by more efficient natural-gas-fired combined-cycle capacity brought online in the past few years and still being constructed (Figure 4). The projected levels of generation from power plants using coal, nuclear, and renewable fuels are higher than in *AEO2002* due to higher projected natural gas prices and uprates and life extensions of nuclear plants.

**Figure 4. Electricity generation by fuel, 1970-2025 (billion kilowatthours)**



The natural gas share of electricity generation is projected to increase from 17 percent in 2001 to 29 percent in 2025, including generation by electric utilities, IPPs, and CHP generators. The share from coal is projected to decline from 52 percent in 2001 to 48 percent in 2025 as a more competitive electricity industry invests in less capital-intensive and more efficient natural gas generation technologies. Nonetheless, coal remains the primary fuel for electricity generation through 2025, and *AEO2003* projects that 74 gigawatts of new coal-fired generating capacity will be constructed between 2001 and 2025.

Nuclear generating capacity is projected to increase slightly from 2001 to 2025 in *AEO2003*. Primarily because of the relatively favorable economics of competing technologies, no new nuclear facilities are expected to be built through 2025; however, fewer expected nuclear retirements (as a result of life

extensions), uprating of existing capacity, and an expectation of higher natural gas prices lead to a projection of more nuclear capacity than in *AEO2002*. No new nuclear power plants have been built in the United States for many years, however, and the economics of new plants are highly uncertain. Total nuclear capacity is projected to increase from 98.2 gigawatts in 2001 to a peak of 100.4 gigawatts by 2006 as a result of uprates before declining to 99.6 gigawatts by 2025. Uprates of 4.2 gigawatts offset retirements of 2.8 gigawatts between 2001 and 2025.

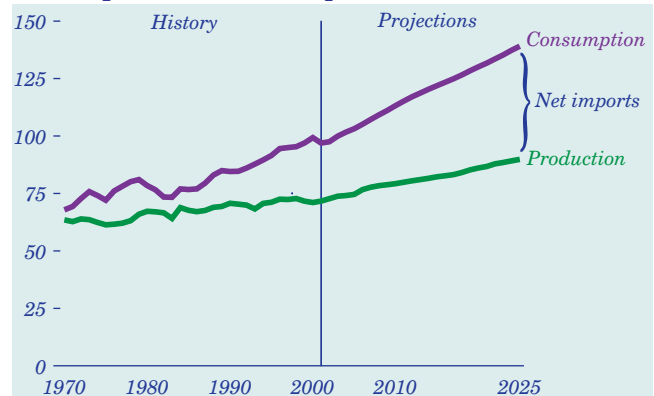
Renewable technologies are projected to grow slowly because of the relatively low costs of fossil-fired generation and because competitive electricity markets favor less capital-intensive natural gas technologies over coal and baseload renewables in the competition for new capacity. Where enacted, State renewable portfolio standards, which specify a minimum share of generation or sales from renewable sources, are considered in the forecast. Federal subsidies for renewables (in particular, wind) are also included in the forecast.

Total renewable generation, including CHP, is projected to increase from 298 billion kilowatthours in 2001 to 476 billion kilowatthours by 2020 in *AEO2003*, an increase of 2.5 percent per year. Growth in renewable generation was projected to grow at a slower 2.1 percent per year between 2001 and 2020 in *AEO2002*. Total renewable generation reaches 495 billion kilowatthours by 2025 in *AEO2003*.

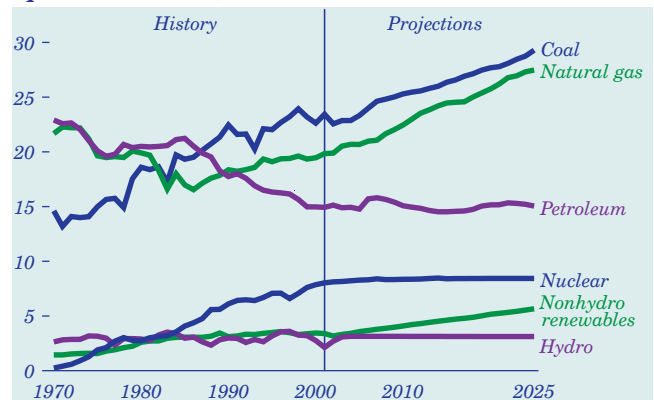
### Energy Production and Imports

Total energy consumption is expected to increase more rapidly than domestic energy production through 2025. As a result, net imports of energy are projected to meet a growing share of energy demand (Figure 5). Projected U.S. crude oil production declines to 5.3 million barrels per day by 2025 in *AEO2003*, an average annual rate of 0.4 percent between 2001 and 2025. Production is 0.2 million barrels per day lower in 2020 than in *AEO2002* due to projected reduced production from the lower-48 onshore by 2020, particularly from enhanced oil recovery (EOR) operations. The lower level of lower 48 production in *AEO2003* relative to *AEO2002* is partially offset by projected increased production from Alaska and higher levels of production from the lower 48 offshore. Total domestic petroleum production (crude oil plus natural gas plant liquids) increases from 7.7 million barrels per day in 2001 to 8.0 million by 2025 due to an increase in the production of natural gas plant liquids (Figure 6).

**Figure 5. Total energy production and consumption, 1970-2025 (quadrillion Btu)**



**Figure 6. Energy production by fuel, 1970-2025 (quadrillion Btu)**



By 2025, net petroleum imports, including both crude oil and refined products on the basis of barrels per day, are expected to account for 68 percent of demand, up from 55 percent in 2001. Despite an expected increase in domestic refinery distillation capacity of 3 million barrels per day, net refined petroleum product imports, on the basis of barrels per day, account for a growing portion of total net imports, increasing from 15 percent in 2001 to 34 percent by 2025.

Driven by growth in natural gas demand, domestic natural gas production is projected to increase from 19.5 to 25.1 trillion cubic feet between 2001 and 2020, an average rate of 1.3 percent per year. Domestic production is increasingly dependent on unconventional and more costly conventional resources in both the onshore and offshore. Projected production in 2020 is 3.4 trillion cubic feet lower than in *AEO2002* because of a reduction in the assumed potential of inferred natural gas reserves, updates to the economics of production, and reduced expectations for technology

improvement for unconventional gas. After 2020, domestic production in *AEO2003* increases noticeably with the projected completion of an Alaskan pipeline. Total domestic natural gas production reaches 26.8 trillion cubic feet by 2025 in *AEO2003*.

Despite the projected increase in domestic natural gas production, an increasing share of U.S. gas demand is met by imports, including pipeline imports from Canada and Mexico (including some from an expected facility in Baja California, Mexico), and LNG. Three of the four existing U.S. LNG import facilities are open, and the fourth has announced plans to reopen in spring 2003; and three of the four have announced capacity expansion plans. Net imports of natural gas are projected to increase from 3.7 trillion cubic feet (16 percent of total demand) in 2001 to 7.8 trillion cubic feet (22 percent of total demand) in 2025.

As domestic coal demand grows in *AEO2003*, U.S. coal production is projected to increase from 1,138 million short tons in 2001 to 1,359 million short tons by 2020, an average rate of 0.9 percent per year. Projected production in 2020 is 38 million short tons lower than in *AEO2002*. By 2025, U.S. coal production is projected to reach 1,440 million short tons in *AEO2003*. Net coal exports are expected to fall throughout the *AEO2003* forecast, reflecting declining coal demand in some countries and intense competition from other international producers.

Renewable energy production is projected to increase from 5.5 to 8.7 quadrillion Btu between 2001 and 2020, with growth in industrial biomass, ethanol, and all sources of renewable electricity generation. Renewable energy production in 2020 is 0.6 quadrillion Btu lower than projected in *AEO2002*, due to lower expected levels of industrial biomass use and generation from geothermal energy, offsetting higher levels of wind energy. By 2025, renewable energy production reaches 9.2 quadrillion Btu in *AEO2003*.

## Carbon Dioxide Emissions

The *AEO* projections do not include future policy actions that might be taken to reduce carbon dioxide emissions. Carbon dioxide emissions from energy use are projected to increase from 1,559 to 2,082 million metric tons carbon equivalent between 2001 and 2020 in *AEO2003*, an average annual increase of 1.5 percent. This forecast is consistent with the 2,088 million metric tons carbon equivalent in 2020 projected in *AEO2002*. By 2025, total carbon dioxide emissions are projected to reach 2,237 million metric tons carbon equivalent in *AEO2003* (Figure 7). While total emissions in 2020 are virtually the same as in *AEO2002*, the amounts vary by sector. Projected industrial carbon dioxide emissions were 5 percent higher in 2020 in *AEO2002* due to differences in the definition of what is included in the industrial sector. As a result of the definitional change, carbon dioxide emissions in the electric power sector are higher in *AEO2003* in 2020 by 6.7 million metric tons carbon equivalent (1 percent). Carbon dioxide emissions are higher by 14.6 million metric tons carbon equivalent in 2020 in the transportation sector in *AEO2003* due to projections of less improvement in vehicle efficiency and more vehicle miles traveled.

**Figure 7. Projected U.S. carbon dioxide emissions by sector and fuel, 1990-2025 (million metric tons carbon equivalent)**

